Available online at www.joac.info

ISSN: 2278-1862

Journal of Applicable Chemistry

2013, 2 (1): 86-90

(International Peer Reviewed Journal)

Spectrophotometric determination of micro amounts of Uranium (VI) using Bromocresol Purple as an analytical reagent

Aparna Bhardwaj*

*Department of Chemistry, B.N. Bandodkar college,Thane, Mumbai

Email: dr.aparna73@rediffmail.com

Received on 31st December and finalized on 10th January 2013

ABSTRACT

Bromocresol Purple dye is used as a reagent for the spectrophotometric determination of Uranium (VI). The reagent forms a Strawberry red colored complex with Uranium (VI) instantaneously at pH 5.0 - 6.0. A six fold molar concentration of the reagent is necessary for the full development of the color intensity. Beer's law is valid over the concentration range 0.2380 -2.142 $\mu g ml^{-1}$. The complex has absorption maximum at 498 nm with molar absorptivity 2.1 × 10^5 $Lmol^{-1}cm^{-1}$ and sensitivity is 4.76 ng ml^{-1} respectively. The standard deviation has been found to be 0.00063.

Keywords: Spectrophotometric determination, Uranium (VI), Bromocresol purple.

INTRODUCTION

It is well known that uranium is toxic as well as being radioactive; the safety profiles for uranium compounds are well established [1,2]. Uranium finds extensive applications as nuclear fuel in power plants. The main sources of uranium are soil, rocks, plants, sand and water. Uranium compounds are carcinogenic and hence there has been some interest in the development of low cost rapid techniques for measuring uranium with some suitable reagents [3-4]. Even though there are many techniques for the analysis of uranium, spectrophotometry [5-16] is widely used due to its simplicity, low cost and adaptability. Hence, it is decided to exploit this technique for the estimation of uranyl ion with Bromocresol Purple. Therefore, there is a need for the development of a simple and selective spectrophotometric method for the estimation of Uranium. The proposed method is based on reaction of uranyl ion with Bromocresol Purple dye in aqueous alcoholic medium to form a Strawberry red colored complex at 498 nm.

MATERIALS AND METHODS

An UV- visible spectrophotometer (ELICO, Model SL-159) with quartz cells of 1.0 cm path length was used for absorbance measurement. An ELICO digital pH (Model LI-120) with combined glass calomel electrode was used for pH measurements. All chemicals used were of AR grade (Merck). A stock solution of Uranyl nitrate of 1.0 × 10^{-2} M was prepared by dissolving the requisite amount of Uranium (VI) in double distilled water and was standardized by known methods reported in the literature[17]. The standard stock solution of Bromocresol Purple of 1.0 × 10^{-2} M concentration was prepared in aqueous alcohol (40%v/v).

Recommended Procedure : An aliquot of solution containing 2.380 µg ml $^{-1}$Uranium (VI) was taken in a 10 ml standard measuring flask, & 6 ml of 1.0×10^{-5} M of the reagent was added to it. The contents were diluted to the mark with aqueous alcohol (40%v/v), keeping the pH constant, the absorption spectrum of the resultant Strawberry red colored Uranium (VI)- Bromocresol Purple complex was recorded against blank from which the value of λ_{max} was obtained.
The optimum experimental conditions in regard to - (1) the concentration of the reagent (Bromocresol Purple); (2) the concentration of the Uranium(VI); (3) the pH of the medium; and (4) ascertaining the λ_{max} of the Uranium (VI) Bromocresol Purple complex were established.

RESULTS AND DISCUSSION

The absorption spectrum of the Uranium (VI)- Bromocresol Purple complex in aqueous alcohol was studied over the wave length range 380-600 nm (Fig. 1). The Strawberry red colored complex exhibited absorption maximum at 498 nm, where reagents shows negligible absorption at this wavelength. The effect of the quantity of the reagent on the intensity of color was also studied. It was found that minimum 6- fold excess of the reagent was required for full color development. The color develops instanteously on mixing the two solutions and remains stable for 20 hours. The optimum pH for the formation of this complex is 5.5.

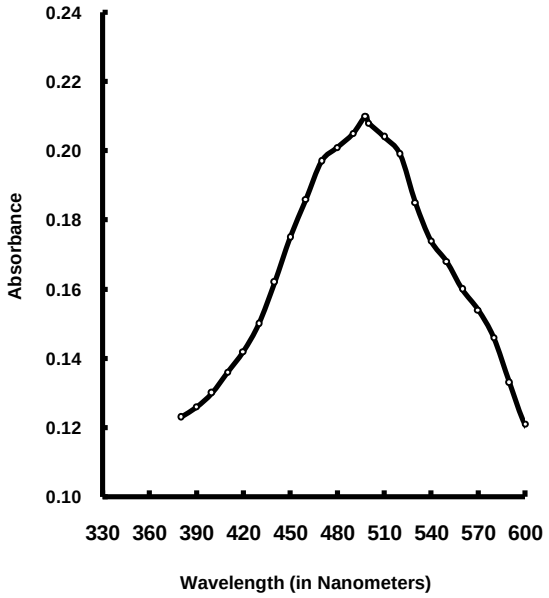

Figure 1: Absorption Spectrum of Uranium (VI)-Bromocresol Purple in aqueous alcoholic medium 40%, v/v*)*

The system adheres to Beer's law in the range 0.0- 2.142 µg ml^{-1} of the Uranium (VI) with optimum range of 0.2380-2.1420 µg ml^{-1} of the metal (Fig. 2). The molar absorptivity calculated over the range studied was 2.1×10^5 L mol^{-1} cm^{-1}, while sensitivity was 4.76 ng ml^{-1}. The standard deviation & coefficient of variance as determined of a series of measurements made according to the optimum conditions were 0.00063 and 0.30 respectively. This speaks the volume for the precision for the present spectrophotometric method for the determination of Uranium (VI) using Bromocresol purple as the analytical reagents. It is worthwhile to mention here that this method has an edge over some recent spectrophotometric methods for the determination of Uranium (VI) using other reagents . Further , the mole ratio method gives the composition of this Uranium (VI)- Bromocresol purple complex as 1:6 (U:BCP::1:6).

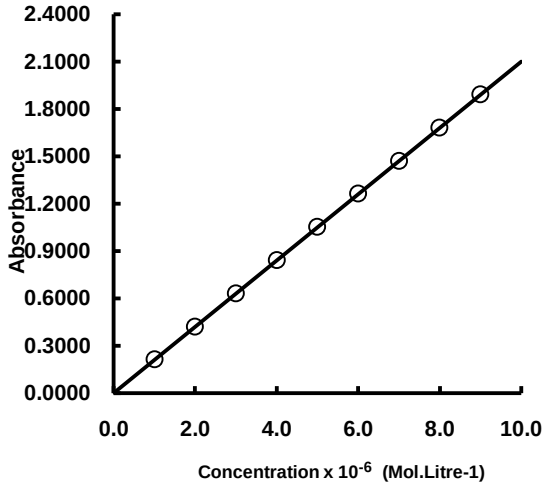

Figure 2: Plot of Absorbance vs Concentration of Uranium (VI) in Uranium (VI) – Bromocresol Purple Complex System at λ_{max} =498 nm

The effect of diverse ions on the spectrophotometric determination of Uranium (VI), using Bromocresol Purple as the reagent has been studied in the terms of tolerance limit which was set as the amount (μg ml^{-1}) of the diverse ions causing an error of ± 1% (Table 1). It has been concluded that the following cations and anions do not interfere in the spectrophotometric determination of the Uranium (VI).

Table 1: Effect of diverse ions on the spectrophotometric determination of Uranium(VI) using Bromocresol Purple as the reagent Uranium (VI) = 0.238 μg mL^{-1}

S. No.	Diverse ions	Added as	Amount of a diverse ion added (μg mL^{-1})	U (VI) found (μg mL^{-1})	Relative error (%)
1	NO_2^-	$NaNO_2$	462.80	0.2357	-0.95
2	NO_3^-	$NaNO_3$	620.20	0.2356	-1.00
3	CH_3COO^{2-}	CH_3COONa	590.40	0.2369	-0.48
4	Cl^-	KCl	710.04	0.2403	0.95
5	Br^-	**KBr**	198.40	0.2357	-0.95
6	I^-	KI	124.60	0.2391	0.48
7	CO_3^{2-}	Na_2CO_3	602.00	0.2369	-0.48
8	SO_4^{2-}	K_2SO_4	95.87	0.2356	-1.00
9	PO_4^{3-}	$Na_2HPO_4.12H_2O$	95.11	0.2346	-1.43
10	NH_4^+	NH_4NO_3	359.04	0.2403	0.95
11	Na^+	$NaNO_3$	229.40	0.2356	-1.00
12	Pb^{2+}	$Pb(NO_3)_2$	207.20	0.2391	0.48
13	Hg^{2+}	$HgCl_2$	200.90	0.2414	1.43
14	Cu^{2+}	$Cu(NO_3)_2.3H_2O$	634.20	0.2369	-0.48
15	Cd^{2+}	$Cd(NO_3)_2$	112.56	0.2369	-0.48

16	Al^{3+}	$Al_2(SO_4)_3.16H_2O$	539.60	0.2414	1.43
17	Fe^{3+}	$FeCl_3$	626.44	0.2391	0.48
18	Cr^{3+}	$CrCl_3.6H_2O$	104.00	0.2403	0.95
19	Zn^{2+}	$Zn(NO_3)_2$	196.08	0.2346	-1.43
20	Mn^{2+}	$MnSO_4.H_2O$	550.00	0.2356	-1.00
21	Ni^{2+}	$Ni(NO_3)_2.6H_2O$	59.00	0.2357	-0.95
22	Co^{2+}	$Co(NO_3)_2.6H_2O$	589.00	0.2369	-0.48
23	Ba^{2+}	$BaCl_2.2H_2O$	137.13	0.2357	-0.95
24	Sr^{2+}	$Sr(NO_3)_2$	882.00	0.2391	0.48
25	Ca^{2+}	$Ca(NO_3)_2$	399.50	0.2391	0.48
26	Mg^{2+}	$Mg(NO_3)_2.6H_2O$	239.70	0.2346	-1.43
27	K^{+}	**KCl**	398.60	0.2403	0.95

APPLICATION

The developed method for the estimation of uranyl ion is effective due to sensitivity, accuracy and can be determined in presence of many foreign ions.

CONCLUSION

The proposed method has the advantage of having high molar absorptivity (2.1×10^5 L mol^{-1} cm^{-1}) with low limit of detection (0.238 µg ml^{-1}). The method is sensitive, accurate and useful due to high tolerance limits from cations and anions. Therefore, the proposed method is an effective method for the quantitative analysis of uranyl ion.

ACKNOWLEDGEMENT

I am thankful to Principal Agra College, Agra to provide necessary facilities to conduct this pioneer study.

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